

NASA TECH BRIEF



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Electron Beam Recrystallization of Amorphous Semiconductor Materials

Semiconductor films are readily formed on an amorphous substrate such as glass or plastic by evaporation or sputtering. The resulting films, however, do not have the crystallinity required for electronic or photovoltaic device applications. In practice, the desired crystallinity can be obtained by maintaining the substrate at an elevated temperature during the semiconductor deposition. One example of this approach is the deposition of cadmium sulfide onto a silver-zinc-coated polyimide sheet during the preparation of thin-film solar cells. A similar accomplishment with higher melting semiconductors such as silicon or germanium has not been achieved because of the temperature limitations of available plastic substrates.

It is known that for certain solid films the change from the amorphous condition to the crystalline involves a reduction in the total energy content of the material. Part of this energy decrement is thought to be the release of strain energy. The ultimate state for such a solid film (i.e., the lowest energy condition) is a single crystal. One method of releasing strain energy, and thereby inducing crystallization, is by electron bombardment. The impinging electrons supply the small amount of activation energy necessary to initiate the release of the strain energy. With electron bombardment techniques, the temperature rise experienced in the film during the onset of crystallization is a fraction of that required to produce melting or sublimation.

In this study, the nucleation and growth of crystalline films of silicon, germanium, and cadmium sulfide on substrates of plastic and glass were investigated. Amorphous films 800 to 300 angstroms (8×10^{-2} to $3 \times 10^{-2} \mu\text{m}$) thick of germanium, silicon, and cadmium sulfide on amorphous substrates of glass and plastic were converted to the crystalline condition by

electron bombardment. Two methods of electron bombardment were employed, namely, electron-beam raster scanning and general surface bombardment. The use of the electron-beam scanning technique to produce a predetermined pattern of crystalline regions in films of the semiconductor material deposited on the amorphous substrates was demonstrated. At electron-beam intensities which produce crystallization of the films, no damage was noted to the plastic material immediately below the treated region. In separate tests, the vacuum decomposition temperature of the plastic material was found to be 250°C .

Order-of-magnitude electrical-resistance measurements were made on 500-angstrom- ($5 \times 10^{-2} \mu\text{m}$ -) thick silicon films before and after crystallization. A resistance decrease of four orders of magnitude was found.

Note:

Documentation for the innovation is available from:

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Technical questions may be directed to:

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No patent action is contemplated by NASA.

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